

U.S. Department of Transportation
Federal Aviation Administration

TRANSFORMER, DISTRIBUTION, PAD-MOUNTED, FOR LOOPED POWER
DISTRIBUTION SYSTEMS WITH HIGH VOLTAGE AT 25KV AND BELOW

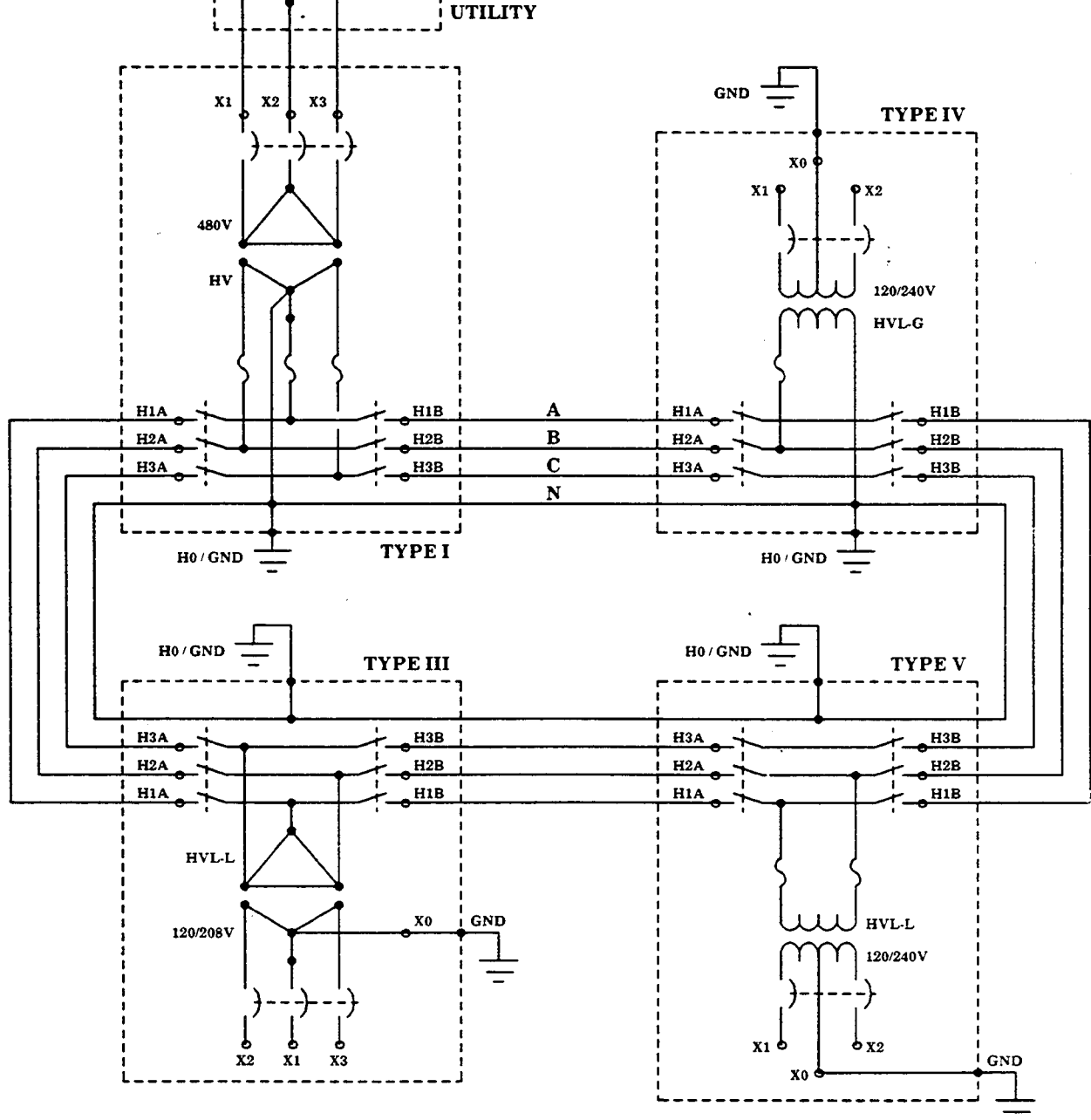
1. SCOPE.- This specification covers oil-filled, pad-mounted, compartmental-type transformers designed in general to comply with the requirements of ANSI standards C57.12.00, C57.12.25 and C57.12.26. These transformers are designed for outdoor installation over a concrete vault or similar structure to provide underground power distribution to FAA facilities via a three-phase, four-wire loop distribution system at various distribution voltages (high voltage not to exceed 25kV, three-phase, line to line). The transformers shall be either single or three-phase, with primary and secondary wiring connections as specified in 1.1 and as indicated in Figures 1 and 2. All transformers shall be configured for loop-feed connections as shown herein. In addition, if requested by the purchaser, the transformers shall include switches meeting the requirements specified herein on the loop-feed connections as shown in Figures 1 and 2.

1.1 Classification.- Six basic types of core-type distribution transformers are covered by this specification. Each type shall have optional loop feed switching as shown in figure 2. The loop-feed switching referred to in this description for types I through V transformers shall consist of two, two-position (open/closed), independently operable three-pole switches; for the type VI transformer, the loop feed switch shall consist of two-pole switches as shown in figure 2. Additional requirements and options for the loop-feed switch are given in 3.9 and 3.10. All required fuses and circuit breakers shall be part of the transformers to be supplied under this specification.

Secondary Voltage	HV*	HV*	120/208	120/240	120/240	HV*
# phases	3	3	3	1	1	1
Primary Phase Config	delta	wye	delta	1 ph/ 1 leg gnded	1 ph/ no gnd	1 ph/ no gnd
Secondary Phase Config	wye/ neut gnded	wye/ neut gnded	wye/ neut gnded	split/ center tap	split/ center tap	1 ph/ 1 leg gnded
Tertiary Winding	none	yes	none	none	none	none
Ckt Bkr	on pri	on pri	on sec	on sec	on sec	on pri
Fuses	on sec	on sec	on pri	on pri	on pri	on sec
Loop Feed	on sec	on sec	on pri	on pri	on pri	on pri

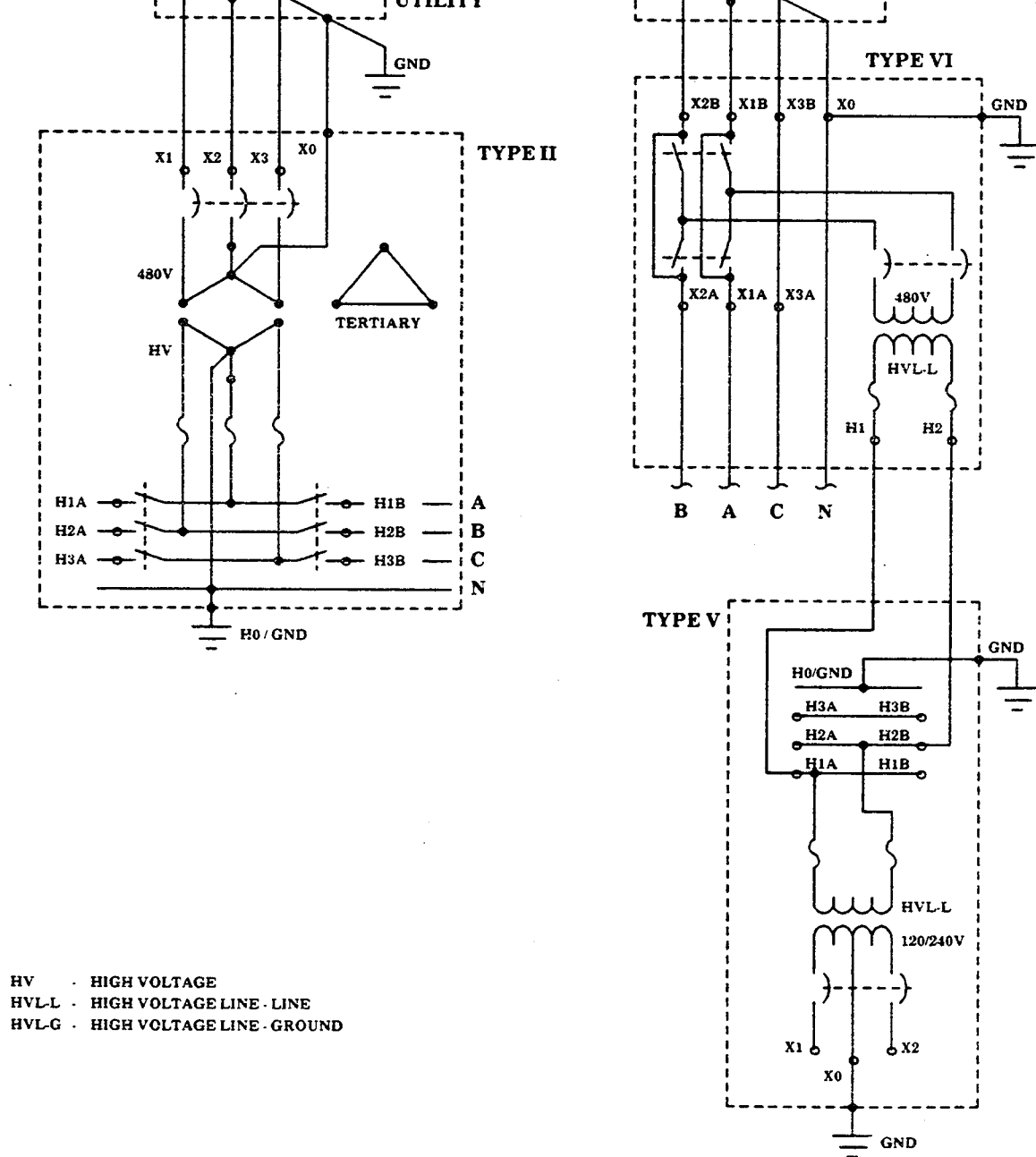
* HV = high voltage, to be specified in purchase order

Figures 1 and 2 following graphically delineate the types of transformers covered in this specification. In the figures, HVLL = high voltage, line-to-line; HVLG = high voltage, line-to-ground; and HV = high voltage, wye-connected, line-line and line-ground.



Note: Loop feed switches shown are optional

Figure 1. Three-Line Diagram Showing Different Transformer Types



Note: Loop feed switches shown are optional.

Figure 1 Three-Line Diagram Showing Different Transformer Types (Cont'd)

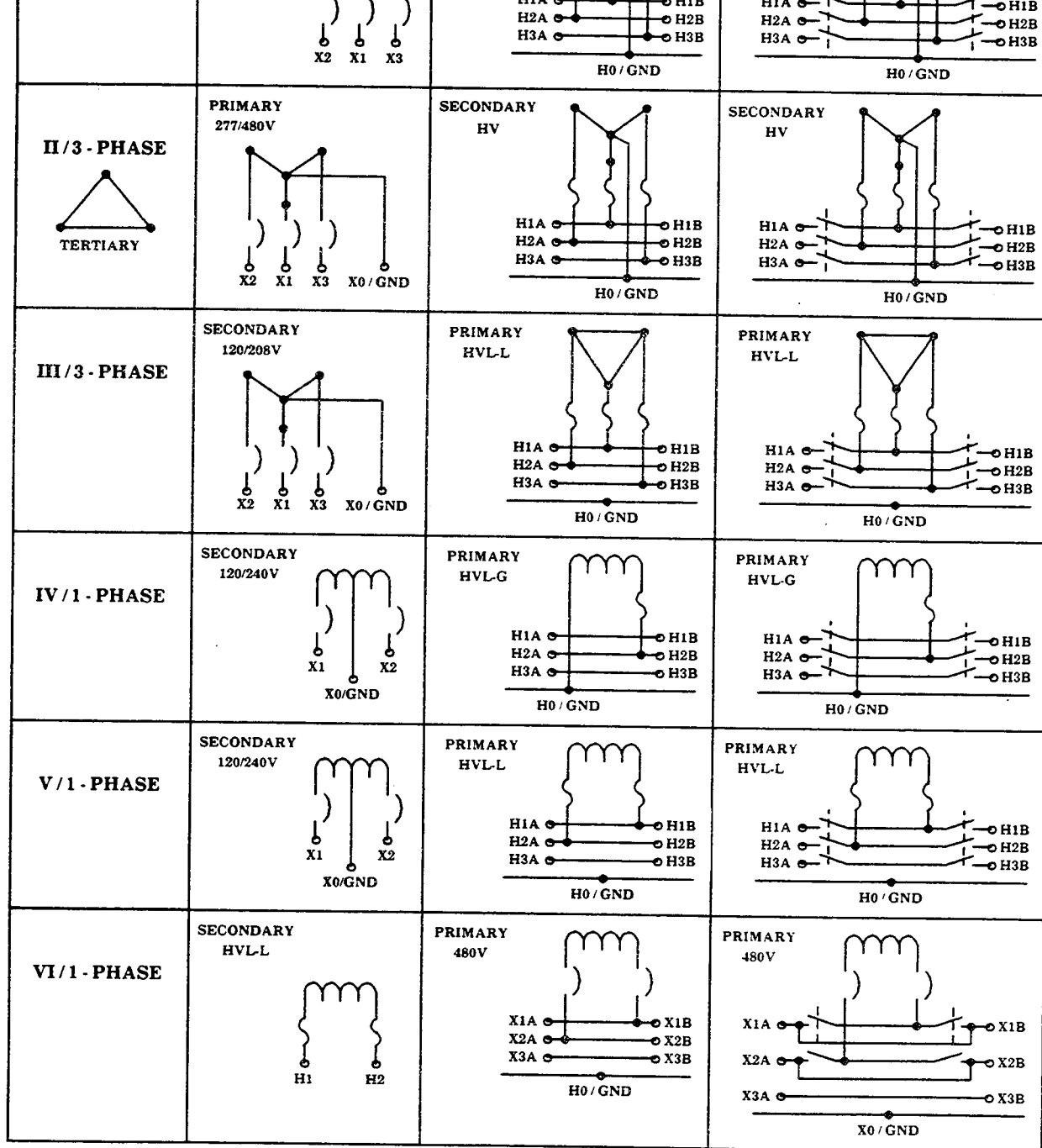


Figure 2 Transformer Schedule

STD 386	Separable Insulated Connector Systems for Power Distribution Systems Above 600V
C37.13	Low Voltage AC Power Circuit Breakers Used In Enclosures
C37.46	Specification for Power Fuses
C57.12.00	General Requirements for Liquid Immersed Distribution, Power and Regulating Transformers
C57.12.25	Pad-Mounted Compartmental-Type, Self-Cooled Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors, High-Voltage, 16,340 GRDY/9,430 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller
C57.12.26	Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, Separable Insulated High-Voltage Connectors; High-Voltage 24,940 GRDY/14,400 Volts and Below; 2,500 kVA and Smaller
C57.12.90	Test Code for Liquid Immersed Distribution, Power, and Regulating Transformers and Guide for Short Circuit Testing of Distribution and Power Transformers
Z35.1	Specifications for Accident Prevention Signs

2.3 FAA Specifications and Standards.- These specifications and standards are available from the Federal Aviation Administration Office issuing the Invitation to Bid.

FAA-STD-013	Quality Control Program Requirements
FAA-G-1375	Spare Parts-Peculiar for Electronic, Electrical and Maintenance Equipment
FAA-G-2100e	Electronic Equipment, General Requirements

B-3	Soft/Annealed Copper Wire
D-244	Impact Resistance
D-256	Charpy Impact Test
D-570	Water Absorption
D-635	Self-extinguishing Flammability Tests
D-638	Tensile Strength
D-695	Compressive Strength
D-790	Flexural Properties
D-2300	Oil Gassing Tendencies
D-3487	Mineral Insulating Oil Used in Electrical Apparatus, Standard Specifications for
D-3951	Standard Practice for Commercial Packaging

2.6 National Fire Protection Association (NFPA) Publications.- This publication is available from NFPA, Batterymarch Park, Quincy, MA 02269.

70	National Electrical Code
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2.7 Military Documents.- Military documents listed below are available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-E-17555	Electronic and Electrical, Packaging of
MIL-I-45208	Military Standard for Inspection System Requirements
MIL-STD-100	Engineering Drawing Practices
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-1381-2	DOD Requirements for a Logistic Support Record
MIL-STD-1561	Provisioning Procedures, Uniform DOD

3. REQUIREMENTS

3.1 Catalog information and shop drawings.- The contractor shall submit to the Contract Officer or the designated agent for approval, eight copies of catalog information and shop drawings, indicating manufacturer, model number, ratings, capacity, and detailed arrangement of components and physical dimensions of unit. These drawings shall be complete and detailed. If approved by the Contract Officer, each copy of the drawings will be identified as having received such approval by being so stamped and dated. The contractor shall make any corrections required by the Contract Officer.

3.1.1 Changes to drawings.- If the contractor considers any corrections indicated on the drawings to constitute a change to the contract, notice as required under the clause entitled "Changes" will be given to the Contract Officer.

3.1.2 Approval of drawings.- The approval of the drawings by the Contract Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Approval of such drawings will not relieve the contractor of the responsibility for any error which may exist, as the contractor shall be responsible for the dimensions and design of adequate connections, details, satisfactory construction of all work, and performance of the transformer for its intended purpose.

3.2 Manufacturers instructions.- The contractor shall provide two copies of the instructions for the installation, operation and maintenance of the transformer to the Contract Officer, and two additional copies with each piece of equipment.

3.3 Construction features.- The following subparagraphs provide information on the features of the transformer tank, grounding provisions, construction of steel and fiberglass compartments, terminals, and installation provisions and marking information.

3.3.1 General.-

- (a) Transformer construction shall conform to ANSI C57.12.25 or ANSI C57.12.26 (single-phase or three-phase), and ANSI C57.12.00, as applicable, except as modified herein.
- (b) The transformer shall consist of the transformer tank with high- and low-voltage cable-terminating compartments.

sticks, rods, or wires might contact electrically live parts, or through which water might enter and cause damage to or loss of function of the transformer.

- (f) The construction shall limit the entry of water (other than flood water) into the compartment so as not to impair the operation of the transformer.
- (g) The transformer shall withstand submergence in 6 ft. of fresh water, while not operating or powered, and shall subsequently meet all requirements of this specification after being dried out.
- (h) All metallic compartment and transformer surfaces shall be treated or designed to minimize corrosion.

3.3.2 Tank.-

- (a) The transformer tank shall be of sealed-tank, all-welded construction.
- (b) The tank shall be made of corrosion-resistant steel.
- (c) All metal surfaces of the tank which could be exposed to the external environment (either directly or through any vents, etc.) shall be coated with chip- and scratch-resistant enamel paint. No metallic-flake paints shall be used on any surface. As a minimum, surface preparation and finish shall consist of the following four-stage process: alkaline cleaning and phosphate treatment; epoxy primer uniformly applied by cationic electrodeposition; impact-resistant polyester intermediate coat applied as a powder electrostatically; and spray-applied alkyd top coat for added UV protection. Color shall be 26493 (light grey semigloss) in accordance with FED-STD-595.
- (d) The tank shall be capable of withstanding a minimum pressure of 7 psig without permanent distortion.
- (e) The tank shall include a pipe plug for filling and pressure testing.
- (f) The tank shall include drain and sampling valves for the fill oil.
- (g) A bolted tamper-resistant handhole with a weather-proof cover accessible from the outside shall be provided in the tank for access to internal connections.
- (h) The tank shall have a dial-type thermometer to measure the top-liquid temperature, with at least a 30° span between minimum and maximum values.

- (1) exposed parts shall be weather and corrosion resistant.
- (2) all materials shall withstand oil vapor and a temperature of 105°C (221°F) continuously without deterioration or affecting performance.
- (3) valve shall include a pull ring for manual operation with a standard hook-stick.
- (4) valve shall withstand a static pull force normal to its longitudinal axis of 100 pounds for 1 minute.
- (5) venting port shall be designed to prevent entry of dust moisture and insects before and after valve actuation.
- (6) valve cracking pressure = 8 to 12 psig.
- (7) valve resealing pressure = 6 psig min..
- (8) there will be no leakage from resealing pressure down to -8 psig.
- (9) valve will be designed for a flow at 15 psig of 35 SCFM.
- (1) Tank shall include oil level and oil temperature transducers for remote maintenance monitoring of these parameters, with the following features:
 - (1) Output of each transducer shall be a 0 to 5 Vdc signal corresponding to the full range of the parameter.
 - (2) Output interfaces shall consist of two (2) properly identified screw-type terminals in a transducer terminal strip.
 - (3) The transducers shall not require external power but shall be powered from the transformer.

3.3.2.1 Tank grounding.-

- (a) For all transformers, tank grounding provisions shall consist of unpainted steel pads welded to the tank, one pad each in the high and the low voltage compartments, located near the base of the compartment.
- (b) For transformers rated 500 kVA and below, each grounding pad shall have a 1/2-13 UNC tapped hole, 7/16 in. deep, minimum.

- (f) The transformer core shall be grounded to the transformer tank for electrostatic purposes.

3.3.3 Compartments.- Full-height terminal compartments with hinged doors shall be located side-by-side, separated by a steel barrier.

3.3.3.1 General requirements.-

- (a) The compartment doors shall latch in the 90° and 180° open positions.
- (b) The hinge assemblies shall be made of corrosion-resistant material. Stainless-steel hinge pins of 3/8-inch minimum diameter shall be provided.
- (c) The high-voltage compartment will be accessible only after the door to the low-voltage compartment has been opened; there shall be at least one additional fastening device which must be removed before the high voltage compartment doors can be opened.
- (d) The doors shall be removable to facilitate making connections and permit cable pulling.
- (e) Both compartment doors must be capable of being secured with a single padlock having a maximum 1/2-inch diameter shackle.
- (f) The compartment shall be capable of withstanding the application of a pry-bar to all joints, crevices, hinges, locking means, etc. in the following manner without having the security of the compartment jeopardized and without affecting the operation of the doors and locks. The tip of the pry-bar shall first be inserted into the opening being tested, with an axial force of 50 pounds. The bar need not be perpendicular to the surface being tested. While maintaining the axial force, a prying force of 300 inch-pounds shall be applied first in one direction and then in the opposite direction (once in each direction). The force shall be maintained in each direction during any relaxation of the compartment assembly. When relaxation ceases, or if no relaxation occurs, the pry bar shall be removed and applied at an untested location. Following the application of this prying force to all available locations on the compartment, an attempt shall be made to insert a probe wire of AWG 10 bare copper, 10 feet long, into all accessible joints and crevices on the external surfaces of the compartments. The probe wire shall not intrude into the compartments' interiors.

assembly. When relaxation ceases, or if no relaxation occurs, the hook shall be removed and applied at an untested handle or any other part which it can engage. Following the application of this pulling force to all available locations on the compartment, an attempt shall be made to insert a probe wire of AWG 10 bare copper, 10 feet long, into all accessible joints and crevices on the external surfaces of the compartments. The probe wire shall not intrude into the compartments' interiors.

- (h) Ventilators shall be permitted and shall be of a size, number and location to allow proper transfer of air through the enclosure. Perforated screens of stainless steel shall be backed with suitable internal baffles to prevent entrance of foreign objects.
- (i) The door to the low voltage compartment shall have a holder for the instruction booklets required by paragraph 3.2.

3.3.3.2 Material requirements.- The compartments shall consist of either a steel or fiberglass NEMA enclosure.

3.3.3.2.1 Steel compartment construction.- Enclosure construction shall meet the type 3R enclosure requirements of NEMA Standard 250, and the Western Underground Committee (WUC) Standard UG-9 requirement for surface and mounted enclosures, and shall have the following features:

- (a) Fabrication of the compartment panels shall be of No. 14 gauge (minimum) hot-rolled sheet steel. In addition to structural members, each sheet steel panel shall have formed edges to supply the required rigidity to the panels. The compartment shall remain rigid and free standing when the doors are open. Construction shall be such that there are a minimum of sheet metal edges exposed to the weather.
- (b) The roof shall be of a design that ensures that water does not collect on it.
- (c) As a minimum, surface preparation and finish shall consist of the following four-stage process: alkaline cleaning and phosphate treatment; epoxy primer uniformly applied by cationic electrodeposition; impact-resistant polyester intermediate coat applied as a powder electrostatically; and spray-applied alkyd top coat for added UV protection. Color shall be 26493 (light gray semigloss) in accordance with FED-STD-595.
- (d) All straps, brackets, bolts, mounting angles and basic framing angles, shall be hot-dipped galvanized after fabrication.

3.3.3.2.2 Fiberglass compartment construction.- Enclosure construction shall meet the type 3R enclosure requirements of NEMA Standard 250, and the Western

- (c) Exterior surface coating shall be ultraviolet light stabilized, weather-resistant, polyester base containing fade-resistant color pigments, and inert extenders to maintain total pigment volume concentration less than 20 percent. Finish color shall be Federal Standard Color No. 14158 (medium green-gray gloss), in accordance with FED-STD-595.
- (d) Interior laminate coating shall be a pigmented, heat-resistant, high-gloss, polyester-base surfacing sealer.
- (e) Organic peroxide catalysts and promoters appropriate to the resin-type shall be used to provide thorough cure.
- (f) The enclosure shall be constructed to meet or exceed the following maximum/minimum structural parameters per Underground Materials specification UG-9:
 - (1) Tensile strength per ASTM D 638: 8,180/17,500 psi.
 - (2) Flexural properties per ASTM D 790: 6,040/12,500 psi.
 - (3) Tangent modules of elasticity: 407.3/453.2 KSI.
 - (4) Compressive strength per ASTM D 695: 19,350/27,000 psi.
 - (5) Water absorption per ASTM D 570: 0.5% max.
 - (6) Charpy impact test per ASTM D 256: 3.0/4.0 Ft lbs.
 - (7) Impact resistance per ASTM D 244: 37.5/52.5 Ft lbs.
 - (8) Flammability tests per ASTM D 635: (self-extinguishing).
 - (9) Ultraviolet protection to be achieved by 0.014 inch exterior gelcoat.
- (g) The roof shall be of a design to ensure that water does not collect on it.
- (h) Visual standards of the finished laminate shall conform to Acceptance Level II of ASTM proposed method for classifying visual defects in glass-reinforced laminate.
- (i) All exterior gelcoat shall be applied to produce a cured film of 0.014 inch plus or minus 0.005 inch in thickness. Distribution of glass reinforcement shall be uniform.

- (1) Ventilators shall be permitted and shall be of size, number and location to allow proper transfer of air through the enclosure. Perforated screens of stainless steel shall be backed with suitable internal baffles to prevent entrance of foreign objects.
- (m) All fiberglass-enclosed transformers shall be mounted on free-standing, galvanized steel or structural aluminum frames attached to the concrete pad. Mounting frames shall provide two grounding clamps, suitable for use with a number 6 bare copper wire, according to FAA-STD-020a, for connection to the system ground. Means for lightning rod installation at all four corners of the roof shall be provided.

3.3.4 Terminals, connectors and bushings.-

- (a) Transformers shall be provided with high voltage bushing wells, bushing inserts and bushings for separable connector systems, which shall meet the requirements of ANSI/IEEE Standard 386. Mating elbows shall not be provided.
- (b) A parking stand shall be provided for each high voltage separable connector (phase and neutral).
- (c) Bushings shall be of the load-break type, in accordance with ANSI/IEEE Standard 386.
- (d) The completely assembled high voltage bushings shall have the voltage ratings and characteristics as shown in the following table, in accordance with ANSI Standard 386: (note: BIL (basic impulse insulation level) is defined as the lightning impulse voltage level that the insulation must withstand; minimum corona voltage level (with 3 pC sensitivity) is defined as the voltage at which corona discharge does not exceed the specified level following the application of a higher voltage)

Max Volt Rating kV	BIL kV	AC Withstand Volt 60Hz for 1 min	DC Withstand Volt for 15 min	Min Corona Volt Level kV
8.3ph-gd	95	34	53	11
8.3/14.4	95	34	53	11
15.2ph-gd	125	40	78	19
15.2/26.3	125	40	78	19
21.1ph-gd	150	50	103	26
21.1/25	150	50	103	26

- (c) Exterior surface coating shall be ultraviolet light stabilized, weather-resistant, polyester base containing fade-resistant color pigments, and inert extenders to maintain total pigment volume concentration less than 20 percent. Finish color shall be Federal Standard Color No. 14158 (medium green-gray gloss), in accordance with FED-STD-595.
- (d) Interior laminate coating shall be a pigmented, heat-resistant, high-gloss, polyester-base surfacing sealer.
- (e) Organic peroxide catalysts and promoters appropriate to the resin-type shall be used to provide thorough cure.
- (f) The enclosure shall be constructed to meet or exceed the following maximum/minimum structural parameters per Underground Materials specification UG-9:
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15.2/26.3	125	40	78	19
21.1ph-gd	150	50	103	26
21.1/25	150	50	103	26

of transformer winding inductive reactance to resistance).

- (4) short-time current rating: 10,000 A rms symmetrical for 0.17 s, and 3500 A rms symmetrical for 3.00 minutes, both with minimum x/r of 6, for 200 A continuous rating, and 25,000 A rms symmetrical for 0.17, and 10,000 A rms symmetrical for 3.00 minutes, both with minimum x/r of 20, for 600 A continuous current rating.
- (f) Low voltage terminals shall be tinned, spade-type connectors with 9/16-inch holes, spaced on 1-3/4-inch centers.
- (g) The completely assembled low voltage connectors/terminals shall have the following electrical characteristics:
 - (1) voltage rating (phase to ground): 1.2 kV.
 - (2) basic impulse insulation level: 30 kV.
 - (3) one-minute withstand voltage: 10 kV, 60 Hz.
 - (4) continuous current capacity of 2000 A.
- (h) High voltage connectors shall be operable by means of a suitable live-line tool which clamps the elbow so that operation is along the probe axis.
- (i) High voltage connectors shall be maintained in place without hold-down bails. The operating force for connector removal/replacement shall be between 50 pounds and 200 pounds, over a temperature range of -20°C (-4°F) to 65°C (149°F).
- (j) Grounding connections shall be as described in paragraph 3.3.2.1 of this specification.
- (k) As shown in Figure 2, all transformers, except Type VI, shall be provided with loop-feed bushings on the high voltage side, i.e. two parallel bushings for each phase, either hard-wired together, or tied together via the optional loop-feed switch. Type VI, shall have the loop-feed connections on the low-voltage side.
- (l) All bushing wells shall be provided with insulated covers meeting the voltage and insulation requirements of 3.3.4.d, and the installation and hold-down requirements of 3.3.4.h and 3.3.4.i, respectively.

shall be provided on the tank, if the tank and termination compartments are made as a single unit or on the tank and compartments if they are separate. The vertical clearance for the jack shall be 1.5 to 6.5 inches. The jack facilities shall be capable of carrying the entire weight of the unit.

3.3.5.2 Rolling/skidding provisions.- The base of the transformer shall be configured for rolling or skidding parallel to and also perpendicular to the centerline of the high voltage bushings. Removable door sills on compartments shall be provided to permit rolling or skidding of unit into place over conduit studs in foundation.

3.3.5.3 Lifting provisions.- Lifting provisions shall be arranged on the tank to provide a distributed balanced lift in a vertical direction for the completely assembled transformer, and shall be designed for a safety factor of 5. This safety factor is the ratio of the ultimate stress of the material used to the working stress. The working stress is the maximum combined stress developed in the lifting provisions by the static load of the completely assembled transformer. The lifting provisions on the three-phase transformers shall be permanently attached; on the single-phase transformers less than 100kVA, they may be removable.

3.3.5.4 Mounting provisions.- Transformer shall be designed to be mounted either on a concrete mounting pad (with cables protruding through the pad), on top of a preformed concrete vault assembly, or partially or completely below ground within a preformed concrete vault assembly.

3.3.6 Marking.-

- (a) The transformer nameplate is to be located in the low-voltage portion of the compartment and shall be readable with cables in place.
- (b) The nameplate shall be permanently affixed to a non-removable part.
- (c) All lettering shall have a minimum height of 0.156 inches.
- (d) The nameplate shall be corrosion-resistant, and shall have the marking permanently engraved or stamped.

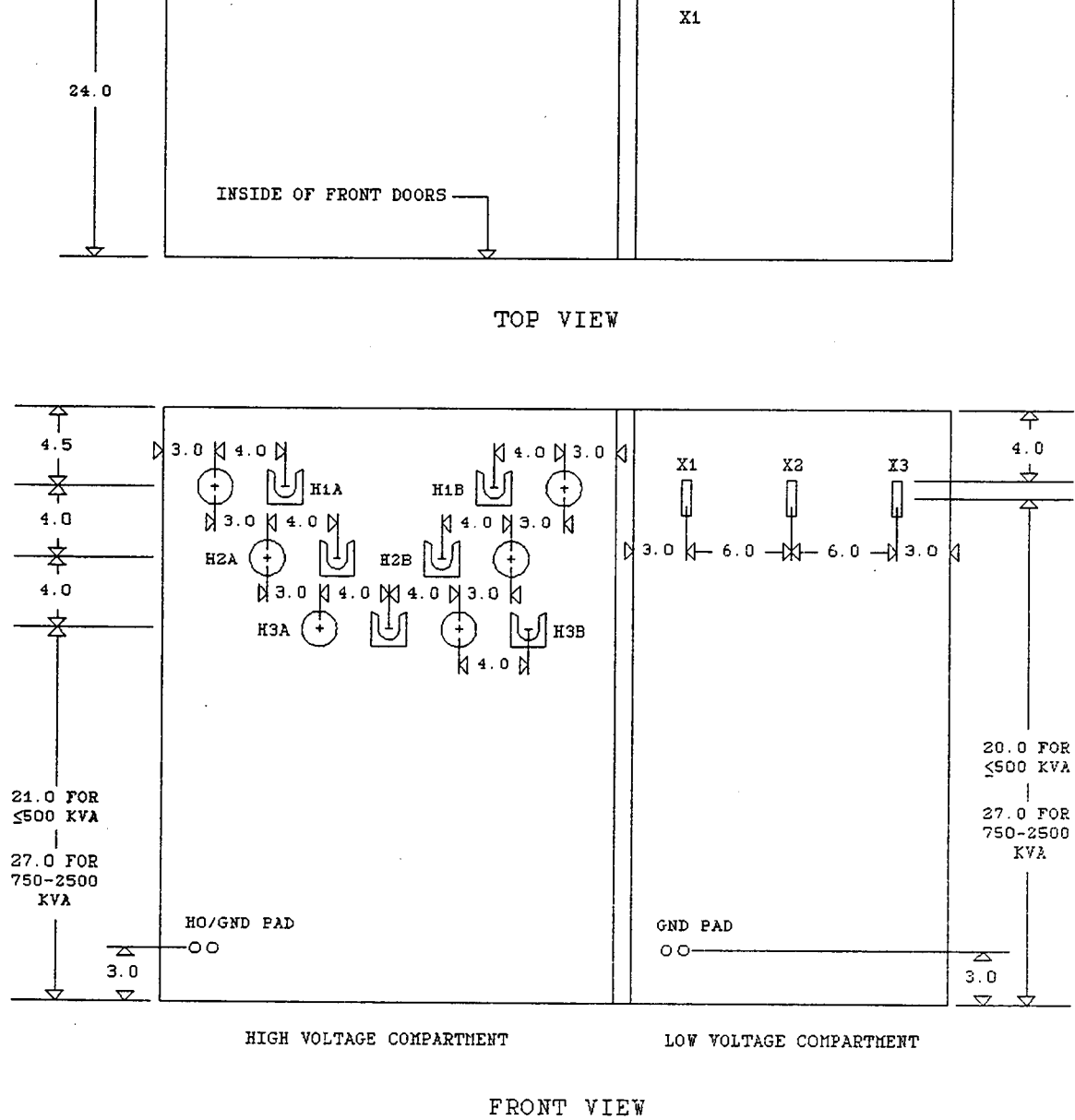


Figure 3. Minimum Dimensions, Type I Transformer

KVA	A	B
25-150	3.0	6.0
225-500	4.0	8.0
750-2500	5.0	8.0

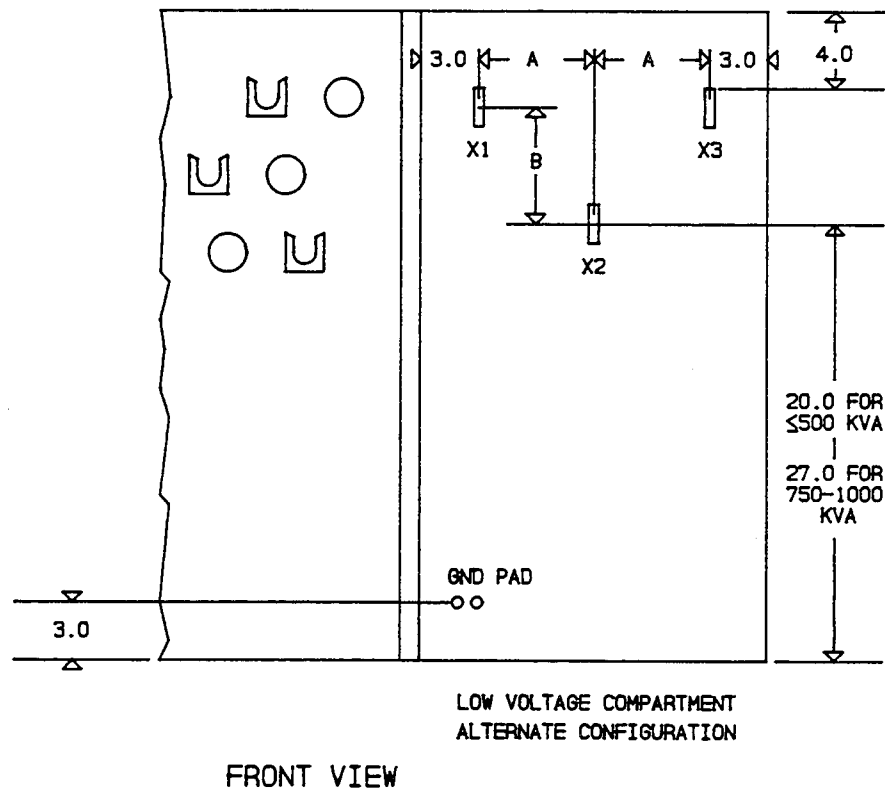


Figure 3. Minimum Dimensions, Type I Transformer (Cont'd)

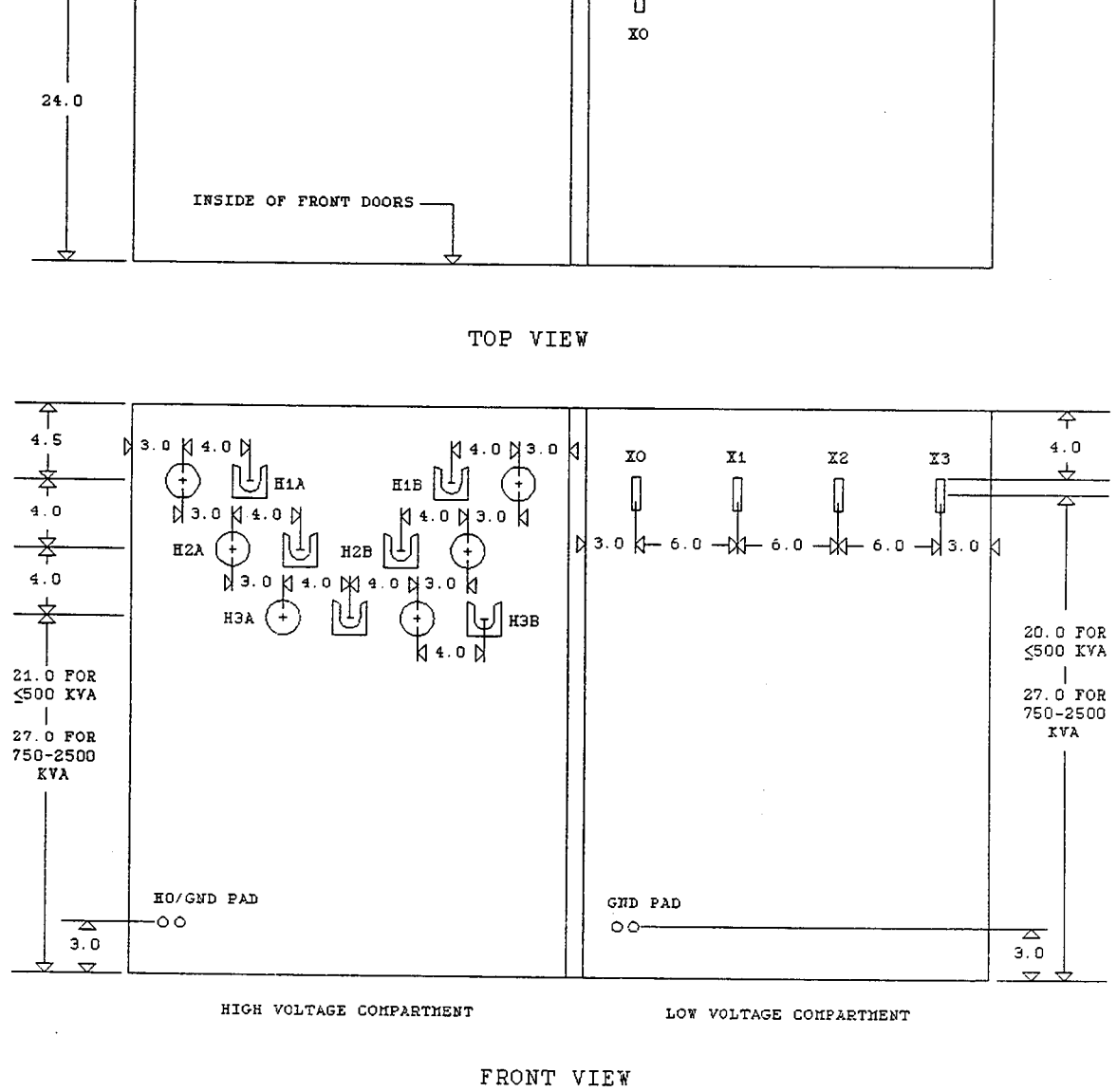
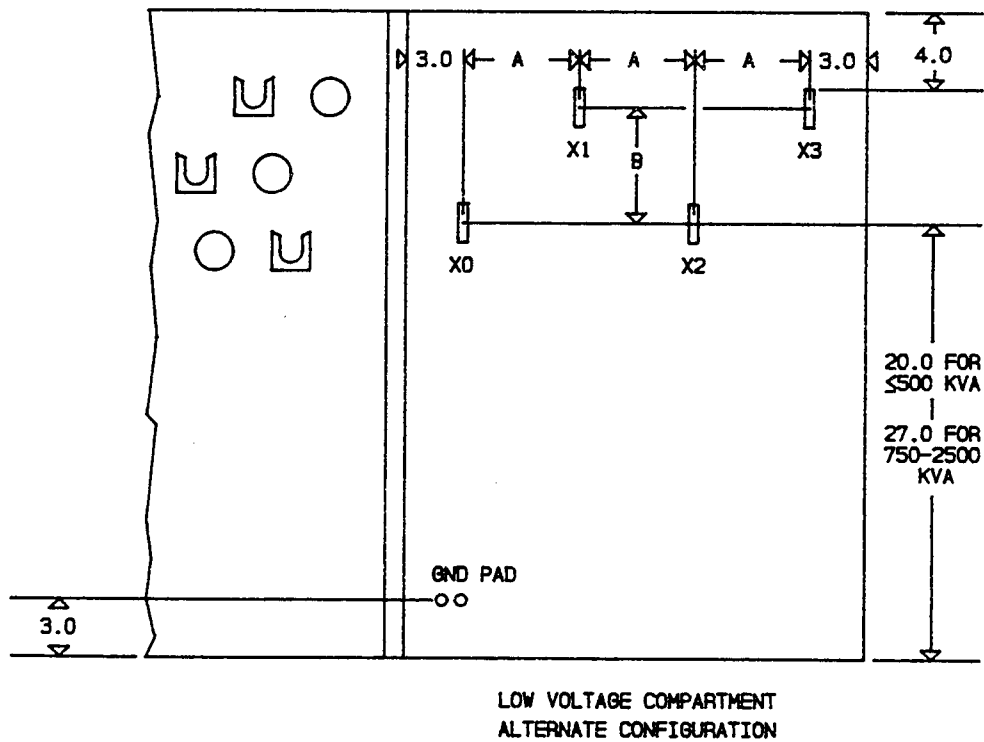


Figure 4. Minimum Dimensions, Type II and III Transformers

KVA	A	B
25-150	3.0	6.0
225-500	4.0	8.0
750-2500	5.0	8.0



FRONT VIEW

Figure 4. Minimum Dimensions, Type II and III Transformers (Cont'd)

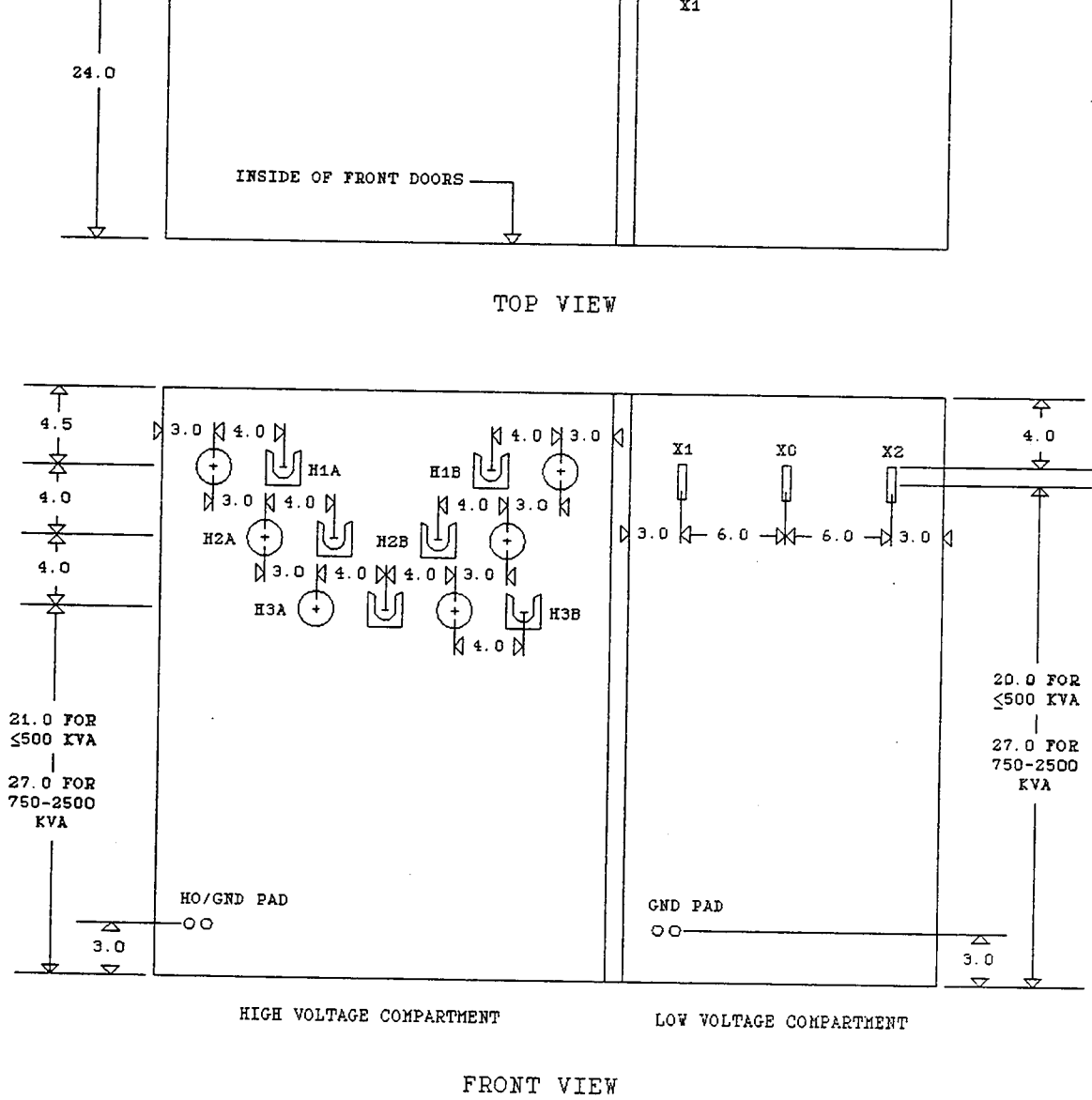


Figure 5. Minimum Dimensions, Type IV and V Transformers

KVA	A	B
25-150	3.0	6.0
225-500	4.0	8.0
750-2500	5.0	8.0

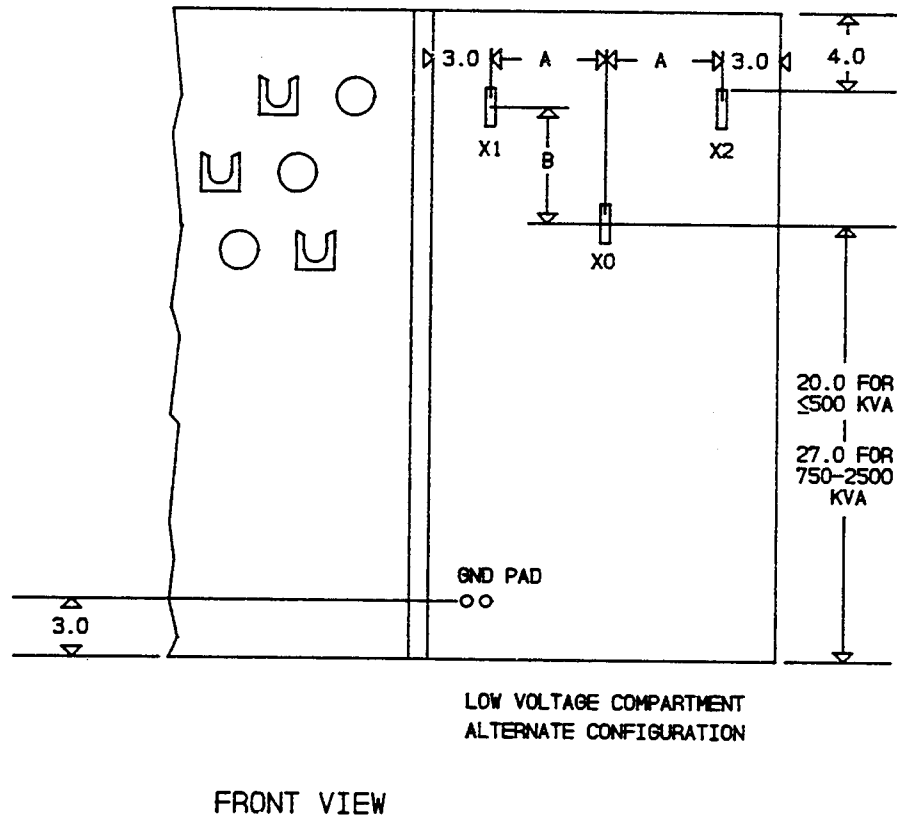
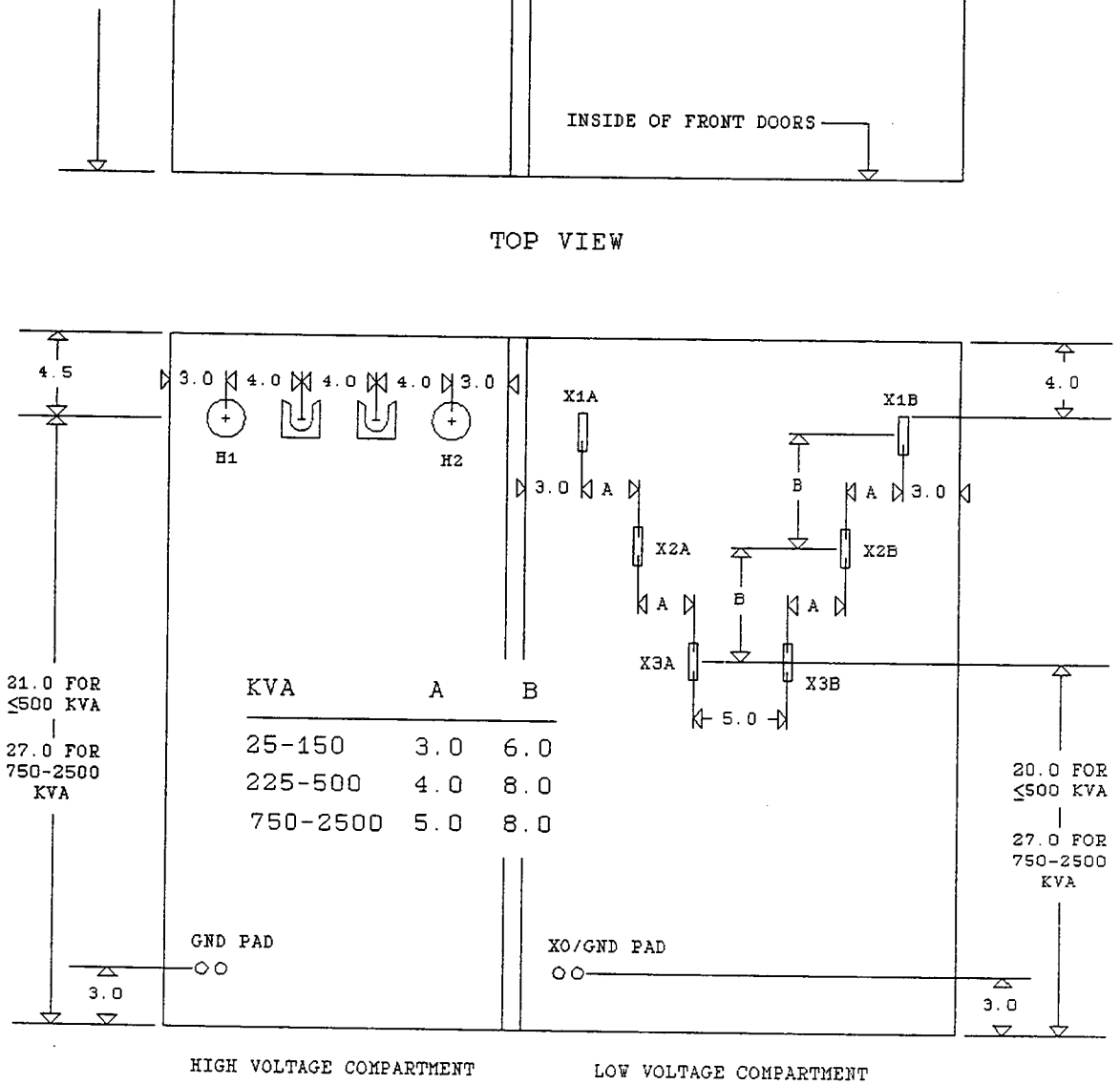


Figure 5. Minimum Dimensions, Type IV and V Transformers (Cont'd)



FRONT VIEW

FIGURE 6

Figure 6. Minimum Dimensions, Type VI Transformer

(list type per specification)

- (d) serial number
- (e) "transformer class OA" (this is defined in ANSI C57.12.00 as a liquid-immersed self/air-cooled transformer)
- (f) number of phases
- (g) with or without loop feed
- (h) kVA (or MVA) rating and frequency
- (i) voltage ratings of each winding
- (j) tap voltages
- (k) temperature rise, in °C
- (l) polarity (for single phase units) or phasor diagram (for polyphase units)
- (m) per cent impedance for each pair of windings
- (n) basic lightning impulse insulation levels (BIL) for each winding
- (o) approximate masses in pounds of core, coils, tank/fittings, liquid, total mass, untanking mass (heaviest piece)
- (p) connection diagram, with all winding terminations identified
- (q) suitability for step-up operation
- (r) maximum operating pressures of liquid preservation system, positive and negative, in psi
- (s) "tank designed for _____psi vacuum filling"
- (t) liquid level below the top surface of the highest point of the highest manhole flange at 25 °C, in inches
- (u) change in liquid level per 10°C change in liquid temperature, in inches
- (v) type of insulating liquid (generic name)

3.4 Electrical requirements.-

3.4.1 Voltage rating.-

- (a) All transformers shall be rated for the low voltages shown in figures 1 and 2 and para. 1.1, and the high voltages specified in the purchase order; voltage ratings shall be at no load, and be based on the turns ratio.
- (b) All taps shall be rated for full capacity.

3.4.2 Single-phase polarity.- Single phase transformers in sizes of 200 kVA and below, shall have additive polarity. Single phase transformers rated above 200kVA shall have subtractive polarity.

3.4.3 Three-phase transformer winding angular displacement.- The angular displacement of a three-phase transformer is the time angle expressed in degrees between the line-neutral voltage of the reference identified high voltage terminal ($H_1, H_2, \text{ or } H_3$ to H_0) and the corresponding identified low voltage terminal (X_1, X_2, X_3 to X_0), and shall be as follows:

- (a) Angular displacement between high-voltage and low-voltage phase voltages for delta-delta or wye-wye connections shall be zero degrees;
- (b) Angular displacement between high-voltage and low-voltage phase voltages for delta-Wye or wye-delta connections shall be 30 degrees, with the low voltage lagging the high voltage.

3.4.4 Insulation levels.-

- (a) When tested in accordance with paragraph 5.10.6 of ANSI Standard C57.12.00, the transformers shall exhibit the following insulation characteristics at the terminations and throughout the windings:
- (b) All windings shall have ungraded insulation (i.e. insulation level of winding shall be uniform throughout winding).

4800	60	19	60	69	1.5	5.0
7200	75	26	75	88	1.6	8.7
12000	95	34	95	110	1.8	15.0
12470	95	34	95	110	1.8	15.0
13200	95	34	95	110	1.8	15.0
13800	95	34	95	110	1.8	15.0
16340	95	34	95	110	1.8	15.0
22860	125	40	125	145	2.25	18.0
13900	125	40	125	145	2.25	18.0
24940	125	40	125	145	2.25	18.0

3.4.5 Kilovolt-Ampere (kVA) ratings.- The transformers shall be available in the following kVA ratings:

Single-Phase Units

Three-Phase Units

5	15
10	30
15	45
25	75
37.5	112.5
50	150
75	225
100	300
167	500
250	750
333	1000
500	1500
833	2000
1250	2500

3.4.6 Duty.- All transformers will be designed for continuous duty at their rated voltage and kVA.

3.4.7 High-voltage taps.-

- (a) Three-phase transformers shall be provided with the following high voltage taps:
- (b) Taps shall be wired to a manually-operated tap-changer, located in the high voltage compartment, which shall be capable of changing taps during unloaded conditions. This tap-changer shall have a positive locking mechanism to prevent accidental tap changes.

7200	table to	above and (2) 2.5%	7560/7380/7020/6840
12000	have (4)	taps below	12600/12300/11700/11400
12470	2.5% taps		13090/12780/12160/11850
13200	below		13860/13530/12870/12540
13800		See entries in 750-	14400/14100/13500/13200
16340	2500 for tap values		17200/16770/15910/15480
22860	all to	all to have (2)	24003/23431/22288/21717
13900	have (4)	2.5% taps each	25095/24497/23302/22705
24940	2.5% below	above and below	26187/25563/24316/23693

All taps shall be permanently connected to windings, i.e. brazed.
(Crimp pressure connections are prohibited).

3.4.8 Temperature rise and loading conditions.- When transformers are loaded as described in 3.4.8.1, observable temperatures shall not exceed the following:

- (a) the average winding temperature rise shall not exceed 65°C (149°F) over an ambient temperature of 0° to 40°C (32° to 104°F), when measured by resistance.
- (b) the temperature rise of the winding hottest spot shall not exceed 80°C (176°F); this shall be measured on qualification test/sampling test units only by installing thermocouples on various locations throughout the windings.
- (c) metallic parts in contact with current-carrying conductor insulation shall not attain a temperature rise in excess of the winding hottest spot temperature rise, and other metallic parts shall not attain excessive temperature rises.
- (d) the temperature rise of the insulating liquid shall not exceed 65°C (149°F) when measured at a depth of 1 to 3 inches.

3.4.8.1 Operation above rated voltage or below rated frequency.- The transformers shall be capable of meeting all other requirements of this specification when operated under either of the following conditions, without exceeding the temperature rises described in 3.4.8 above.

- (a) Continuous operation above rated voltage or below rated frequency, at maximum rated kVA for any tap, when all the following conditions exist:
 - (1) secondary voltage and volts-per-hertz do not exceed 105 per cent of rated values;
 - (2) load power factor is 80 percent or higher;

listed below. These short circuits shall include three-phase, single line-to-ground, double line-to-ground, and line-to-line faults on any one set of terminals at a time. The transformers shall meet all requirements of this specification after being subjected to these short circuits.

3.4.9.1 Short circuit current duration.- All types and kVA ratings of transformers shall withstand the short circuit current defined in 3.4.9.2 for 0.25 sec.

3.4.9.2 Short circuit current.-

- (a) The ability to withstand short circuits shall be demonstrated by creating actual short circuits on the secondary of each type and size of transformer. The no-load supply voltage shall not exceed 110 percent of rated value. During application of the short circuit, the supply voltage shall be maintained at 95 to 105 percent of rated value.
- (b) The shorts shall include all the types of shorts listed in 3.4.9 above.
- (c) Short circuit current magnitude: For transformers rated over 500kVA, the symmetrical short circuit current which the transformer must withstand shall be calculated as follows:

$I_{SC} = \text{Short circuit current} = I_R / (Z_t + Z_s)$ where:

I_R = rated current on the given tap connection, in rms amperes;

Z_t = transformer impedance on the given tap connection, in per unit on the same apparent power base as I_R ;

Z_s = impedance of the system or permanently connected apparatus, in per unit on the same apparent power base as I_R .

For transformers rated at 500kVA or less, the symmetrical short circuit current shall be the same as shown above, except that the maximum symmetrical current magnitude shall not exceed the withstand capability listed below:

1-phase kVA	3-phase kVA	withstand capability per unit of base rated current (symmetrical)
5-25	15-75	40
37.5-100	112.5-300	35
167-500	500	25

which electric failure or breakdown of the insulation occurs.

- (a) As a minimum, for single phase transformers, the transformer shall withstand an AC voltage applied between the terminals of the low-voltage winding that will induce a voltage of 1000 volts plus 3.46 times the rated high-voltage winding voltage between the high voltage line terminals and ground.
- (b) As a minimum, for three-phase transformers, the transformer shall withstand an AC voltage applied between the terminals of each low voltage winding that will induce a voltage of 1000 volts plus 3.46 times the rated high voltage phase to phase winding voltage between the high voltage line terminals and ground.

3.4.11 Conductors.-

- (a) Windings and leads shall be made of soft-drawn or annealed copper in accordance with ASTM Standard B3, with a mass resistivity of 875.20 ohm-pounds per mile².
- (b) Windings shall be solid, single-strand conductors, with insulation of a type compatible with the oil insulation specified in para. 3.5.
- (c) All leads between the core and the terminals shall be stranded, with insulation of a type compatible with the oil insulation specified in para. 3.5.

3.4.12 Impedance voltage.- The impedance voltage is defined as the voltage required to circulate rated current through the primary winding of the transformer when the secondary winding is short-circuited. There is no specific required impedance voltage for single-phase transformers, nor for three-phase transformers rated at 500 kVA and below. For three-phase transformers rated between 750 and 2500 kVA, the impedance voltage shall be 5.75 ± 0.25 per cent. The manufacturer shall state the actual impedance of each unit, three-phase and single-phase, on the unit's nameplate.

3.4.13 Service conditions.- The transformers shall be designed to meet all requirements of this specification, under the following conditions:

- (a) Ambient temperature of cooling air shall not exceed 49°C (120°F)
- (b) Top liquid temperature of the oil shall not be lower than -40°C (-40°F)

- (e) The load current shall be approximately sinusoidal, and the harmonic factor shall not exceed 0.05 per unit.
- (f) All units shall be suitable for outdoor operation.
- (g) Over voltage and under frequency limits shall be as stated in 3.4.8.1 of this specification.

3.4.14 Efficiency.- The transformers shall have a minimum efficiency of 90 percent at rated full load, where efficiency is defined as the ratio of the total power input to the transformer to the useful power output from the transformer.

3.4.15 Audible noise.- When measured in accordance with Section 13 of ANSI Standard C57.12.90, the "A-weighted" audible sound levels emitted by the transformer assembly at the distances specified below shall not exceed the following:

Equivalent two-winding kVA	Average sound level, dB
0 to 50	48
51 to 100	51
101 to 300	55
301 to 500	56
750	57
1,000	58
1,500	60
2,000	61
2,500	62

All sound levels shall be measured at half-height, 1 foot perpendicular, from the surface of the transformer (except that if fans are used for cooling, the sound shall be measured 6 feet perpendicular from any portion of the transformer cooling surfaces or tubes cooled by forced air). The intervals between measurement locations around the transformer shall not exceed 3 feet.

3.4.16 Loss of primary input phase on three-phase transformers.- When the primary voltage on one phase or two phases of a three-phase transformer is absent, there shall be no measurable or detectable voltage present on the corresponding secondary phases (i.e. the primary voltage on the remaining one or two phases shall not create a "phantom voltage" on the secondary phase with the absent primary voltage). The use of a triplex core is an acceptable means of achieving this requirement.

following properties:

3.5.1 Physical properties.-

- (a) Aniline point = 63 to 84 °C (145 to 183 °F); the aniline point is the lowest temperature at which the oil and the liquid Aniline ($C_6H_5NH_2$) are completely miscible; this serves as an indication of the type of hydrocarbons present in the oil.
- (b) Max. color number - 0.5.
- (c) Flashpoint = 145°C (293°F).
- (d) Min. interfacial tension at 25°C = 40 dynes/cm.
- (e) Max. pour point = -40°C (-40°F).
- (f) Specific gravity at 15°C = 0.91.
- (g) Max. viscosity at 0/40/100 °C (32/104/212 °F) = 76.0/12.0/3.0 cSt.
- (h) Visually the oil shall appear clear and bright.

3.5.2 Electrical properties.-

- (a) Dielectric breakdown voltage at 60 Hz, using VDE electrodes with 0.040/0.080 gap = 28/56 kV min.
- (b) Dielectric breakdown voltage under impulse conditions, at 25°C needle negative to sphere grounded, 1-inch gap = 145 kV min.
- (c) Max. gassing tendency = +15 microliters/min, when tested per ASTM Std. D 2300 procedure A.
- (d) Power factor at 60 Hz, at 25/100 °C = 0.05/0.30 percent max.

3.5.3 Chemical properties.-

- (a) Oxidation stability (acid sludge test), 72h = 0.1 percent sludge by mass, max.
- (b) Oxidation stability (acid sludge test), 72h, total acid number, mg KOH/g = 0.3 max.
- (c) Oxidation stability (acid sludge test), 164h = 0.2 percent sludge by mass, max.

(i) Neutralization number, total acid number, mg KOH/g = 0.03 max.

3.6 Fuses.- All ungrounded leads from the windings on the high voltage side shall be protected by current-limiting fuses.

3.6.1 Fuse requirements.-

- (a) Fuses shall be of a kind commercially available, and of a standard industry design.
- (b) Fuses shall meet all requirements of ANSI Standard C37.46, for E-rated fuses.
- (c) Fuses shall have delayed-response tripping.
- (d) Fuses and holders shall be oil-immersed.
- (e) Fuses and holders shall be designed for fuse removal and replacement without draining off oil.
- (f) Fuses shall be the disposable cartridge type; refill-type units or internal expulsion fuses shall not be used.
- (g) Fuses shall be appropriately rated for the system high voltages (up to 25 kV) and the required kVA, at 60 Hz.
- (h) Fuses shall have a rated maximum rms interrupting current of at least 50,000 amperes symmetrical and 80,000 amperes asymmetrical.
- (i) Fuses and fuse holders shall have the following crest BIL voltages (for 1.2 x 50 microseconds), 60 Hz. withstand voltages (for 1 minute), and impulse withstand voltages (for 1.2 x 50 microseconds):

rated volt kV	BIL kV	terminal - ground withstand volt, kV	terminal - terminal withstand volt, kV	term - term impulse volt, kV
2.8	45	15	17	50
5.1	60	19	21	66
5.5	60	19	21	66
8.3	75	26	29	83
15	95	36	40	105
15.5	110	50	55	121
25	150	60	66	165

necessary for fuse replacement.

- (k) Fuses shall be available in the following standard continuous current ratings: 0.5, 1, 2, 3, 5, 7, 10, 15, 20, 25, 30, 40, 50, 65, 80, 100, 150, 200, 250, 300, and 400 amperes. The fuse continuous current rating shall correspond as closely as possible to the expected high voltage side current draw, based upon the kVA rating (the next higher rated fuse may be used if the fuse and expected current ratings are not equal).
- (l) Fuse holders shall be available in the following continuous current ratings: 10, 25, 100, 150, 200, 300, 400, 450, and 700 amperes. The holder shall be rated at the same or higher continuous current level as the fuse.
- (m) Fuses shall not be of the expulsion type.

3.7 Circuit breakers.- All transformers shall have a molded-case, commercially available circuit breaker, meeting the requirements of ANSI Standard C37.13 and NEMA Standard AB-1, providing overload protection on each ungrounded low voltage leg.

3.7.1 Circuit breaker characteristics.-

- (a) Transformer shall have a standard molded-case circuit breaker on each ungrounded low voltage leg (on three-phase and 120/240 split phase). The tripping of the breaker on any leg shall cause the breakers on all the legs to trip simultaneously.
- (b) Insulation class shall be Class 105 (rated for 105°C/221°F).
- (c) Breaker shall be of the unfused type.
- (d) Breaker trip element shall be direct acting, thermal-magnetic type, and shall be temperature-compensated to operate correctly within the temperature range of -25°C (-13°F) to 49°C (120°F).
- (e) Breaker shall be able to continuously carry the current associated with the rated low voltage and kVA.
- (f) Breaker shall be capable of interrupting a minimum symmetrical short circuit current based upon the transformer kVA rating and percent impedance as specified in the following formula:

$$I_{scmax} = (100\%/Z_t) \times I_{FLsec}, \text{ where:}$$

I_{scmax} = maximum symmetrical short circuit current

pairs of properly identified terminals for connection of the external 12 Vdc or attachment of the external contacts to open and close the breaker contacts. The maximum input current for the 12 Vdc control shall be 2 amps at 12 volts DC.

- (h) Breakers shall be locally manually operable.
- (i) Breakers shall have local contact position indication, as well as contacts for remote contact position indication, which shall be brought out to pairs of terminals in the same terminal strip as (g) above. The contacts shall be capable of carrying 10 Amps at 120 Vac.
- (j) Breakers for three-phase transformers with grounded-wye windings on the low-voltage side or single phase transformers with low-voltage grounded windings shall have ground fault protection with programmable trip current and time delay.
- (k) All terminals for indication and control, as specified above, shall be located in the same terminal strip, and shall be accessible for connection without removal of other components.

3.7.2 Circuit breaker mounting.- The circuit breaker(s) shall be mounted on the wall of the low voltage compartment, with all leads to and from the breaker brought through the tank wall in sealed conduit behind the breaker. There shall be no exposed leads from the windings to the breaker or from the breaker to the low-voltage terminals.

3.8 Optional current and voltage transducers/transformers.- If so specified in section 6, current and voltage transducers with current and potential instrument transformers shall be provided in the quantities and locations shown in the tables in item (a) below. Current transformers shall be of the pass-through (non-contact) type. Both current and potential transformers shall be of a standard, commercially-manufactured type.

II	pri: 4 (1/ph & neut) sec: 8 (H1A, H2A, H3A, H1B H2B, H3B & N in/out)	12
III	pri: 8 (H1A, H2A, H3A, H1B H2B, H3B & N in/out) sec: 4 (1/ph & neut)	12
IV	pri: 6 (H1A, H2A, H3A, H2B & N in/out) sec: 3 (X1, X2 & X0)	9
V	pri: 6 (H1A, H2A, H3A, H1B H2B, & N) sec: 3 (X1, X2 & neut)	9
VI	pri: 6 (X1A, X2A, X3A, X1B X2B, & N) sec: 2 (H1 + H2)	8

Xfmr Type	no./locat. voltage transformers	Total No. of Transducers
I	pri: (1) 3-ph; delta-conn. sec: (1) 3-ph; wye conn.	(3) ph to ph on pri (3) ph to neut on sec
II	pri: (1) 3-ph; wye conn. sec: (1) 3-ph; wye conn.	(3) ph to neut on pri (3) ph to neut on pri
III	pri: not measured sec: none required	(3) ph to neut on sec
IV	pri: not measured sec: none required	(2) ph to neut on sec
V	pri: 6 not measured sec: none required	(2) ph to neut on sec
VI	pri: (1) 3-ph, wye conn. sec: 1 1-ph	(3) ph to neut on pri (1) ph to ph on sec

current ratio shall be dependant upon the rated kVA in the following manner: $(150 \text{ percent of rated secondary current})/5$. If the primary value does not correspond to a standard manufactured unit, then the next higher available standard unit shall be used. Accuracy shall be 1 percent. The contractor shall provide typical excitation curves as part of the documentation.

- (e) Potential transformers shall be provided as necessary to be used in conjunction with the voltage transducers specified in 3.8 above, to bring the measured voltage to within the required 0 to 120V ac range. With loss of one or more phases of the potential transformer primary, there shall be no measurable voltage on the corresponding secondary phase. The potential transformer shall be capable of producing up to 5 A per phase on the secondary when the primary is excited to its rated voltage.
- (f) The transducers shall obtain their operating power from the transformer; external power shall not be required.
- (g) Each transducer specified in 3.8.a above shall have two terminals for output. All terminals shall be presented for purchaser connection on one or more terminal strips located in the same area and shall be accessible for connection without removal of other components.

3.8.1 Space for purchaser-supplied transducers and transformers.- If the current/voltage transducer option specified in 3.8 above is not chosen, then the space required for the future installation of the quantities of transducers and transformers shown in 3.8(a) above shall be provided in the high and low voltage compartments and the control enclosure for purchaser installation.

3.9 Optional loop feed switching.- When specified on the purchase order, loop feed switching located within the transformer and wired as shown in Figure 2 shall be provided and shall have the following characteristics:

- (a) Each side of the switching mechanism, consisting of three individual switches, shall be gang-operated (i.e. all three phase contacts are switched as a unit), and shall operate independent of the other side.
- (b) Switches shall be oil-immersed, load-break type.
- (c) Minimum nominal voltage rating 8.3 KV.
- (d) Minimum continuous rating at 5 KV - 200 amps 60 Hz AC and an interrupting capability of 12 KA symmetrical.
- (e) 95 KV basic insulation level (BIL) at 8.3 KV.

operations.

- (j) Switches shall be capable of functioning in ambient temperatures of -20°C to +65°C (-4°F to 149°F).
- (k) There shall be visual indication of the switch for both the closed and open positions.
- (l) All connections from the high voltage connectors to the switch terminals shall be internal; only the three pairs of high voltage phase lines/connectors and the neutral line, if required, shall be present within the compartment.
- (m) The switch shall be equipped with an internal operating mechanism designed so that the speed of opening and closing of the interrupter contacts will be independent of the external operator. All contacts for each three-phase gang shall operate simultaneously, within 4 milliseconds.
- (n) Neutral line shall not be switched, but shall remain connected to the transformer ground pad(s).

3.10 Optional mounting for government-supplied hydraulic actuation.-

- (a) If specified on the purchase order, the transformers with loop-feed switching shall be provided with switch handles and mounting bosses and pads as shown in Figure 7.
- (b) There shall be one switch handle for each gang of switches.
- (c) The switch handle shall be able to be operated manually, using a hook-stick.
- (d) The switches shall be mounted such that their horizontal centerlines and the horizontal centerlines of the pads described in (f) below align vertically to within a tolerance of $\pm 1/32$ inch. Horizontal spacing between switch centerlines shall be as required by the manufacturer, but shall be fixed for all kVA ratings of transformer obtained under this specification (including all future orders. The manufacturer shall provide the horizontal spacing information to the contract officer as soon as the order is placed or the design is fixed.
- (e) There shall be no other protrusions such as bushings, parking stands, tap changers, circuit breakers or fuses in a horizontal band ranging from 7 inches above the centerline of the switches to 7 inches below the centerline of the switches.

outside of the high voltage compartment. There shall be two grommetted 2-in. diameter holes connecting this enclosure with the high voltage compartment.

3.11 Reliability requirements.- The equipment shall meet the following reliability figures of merit:

- (a) The mean time between failure (MTBF) for all types shall not be less than 180,000 hours.

3.12 Maintenance requirements.-

3.12.1 Interchangeability.- Interchangeability of serviceable modules and parts shall be in accordance with FAA-G-2100e.

3.12.2 Serviceability.- All serviceable components shall be mounted and located so that they may be readily accessed and removed for service or replacement.

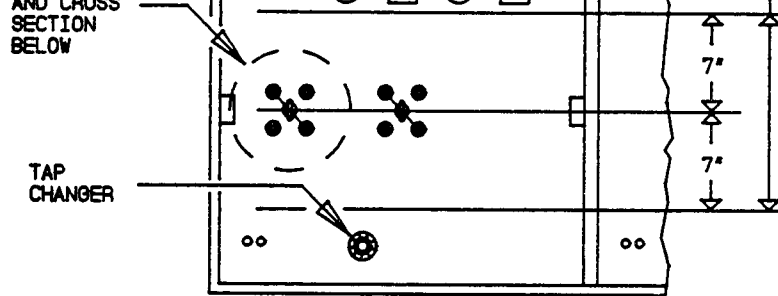
3.12.3 Configuration control.- Changes which affect the operation, installation, servicing, mounting configuration, or functional characteristics of the equipment must have the prior approval of the Contracting Officer.

3.12.4 Maintainability requirements.- The equipment shall meet the following maintainability requirements:

- (a) The mean time to repair shall not exceed 4 hours.
- (b) No more than 4 hours per year preventive maintenance shall be required.
- (c) The equipment shall be maintainable using standard tools and test equipment.

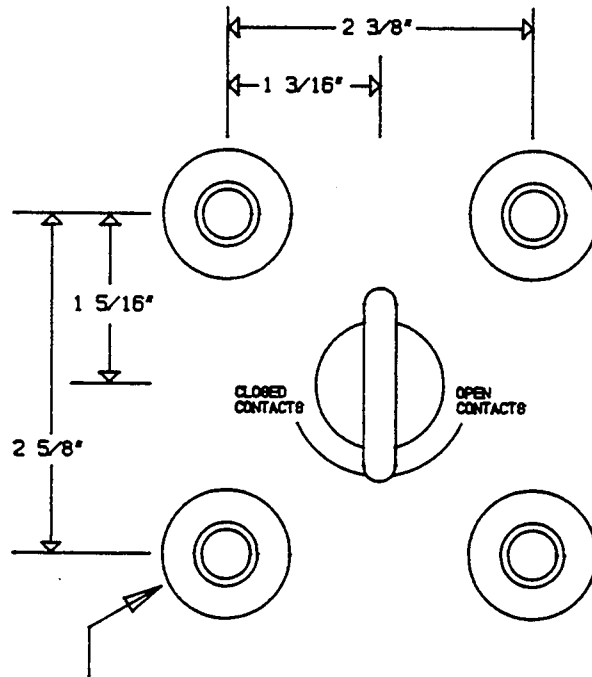
3.13 Documentation.- Data generated during the development of oil-filled, pad-mounted, compartmental-type transformers shall be documented in drawings and parts lists. Engineering drawings shall be prepared in accordance with DOD-D-1000 and DOD-STD-100. Parts lists in hard copy used for provisioning shall be formatted in accordance with FAA-G-1375 for spare parts-peculiar and MIL-STD-1561 for all other lists. Parts lists for provisioning developed from Logistics Support Analysis (LSA) shall be formatted in accordance with MIL-STD-1388-2 and documented in an automated media compatible with the FAA-approved LSA automated database.

3.14 Logistics.- Logistics support for the equipment provided under this specification shall be in accordance with MIL-STD-1388-1 and MIL-STD-1388-2.



TYPICAL HIGH VOLTAGE COMPARTMENT

NOTE
LOOP FEED SWITCHES, FUSE, AND
TAP CHANGER MAY BE LOCATED AS
REQUIRED BY MANUFACTURER WITHIN
THE CONSTRAINTS IMPOSED BY THIS
SPECIFICATION, PROVIDING THEY
ARE CONVENIENTLY ACCESSIBLE
FROM THE OUTSIDE WITHOUT CABLE
OR HARDWARE REMOVAL.



TYPICAL OF 4 BOSSES PER SWITCH.
EACH BOSS TO BE 1" DIAM. WITH
A DRILLED, 3/8-16 UNC TAPPED
HOLE IN CENTER

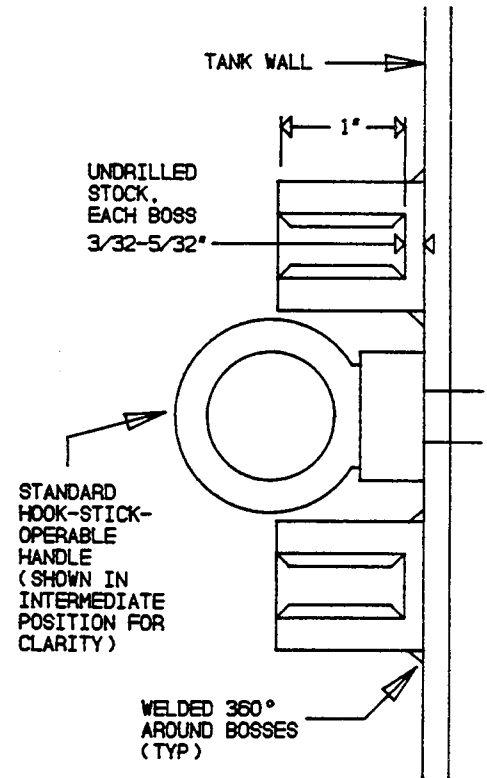
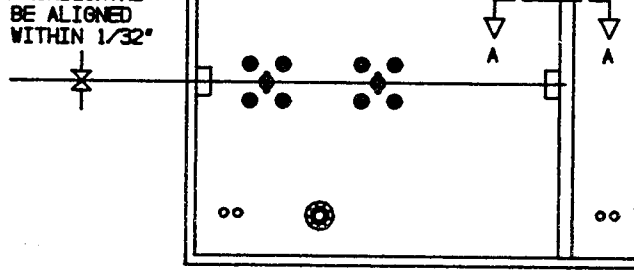


Figure 7. Interface Dimensions for Supplier-Provided Hydraulic Loop-Feed Switch

CENTERLINE TO BE ALIGNED
VERTICALLY TO WITHIN 1/32"



TYPICAL HIGH VOLTAGE
COMPARTMENT

SECTION A-A (ROTATED 90°)

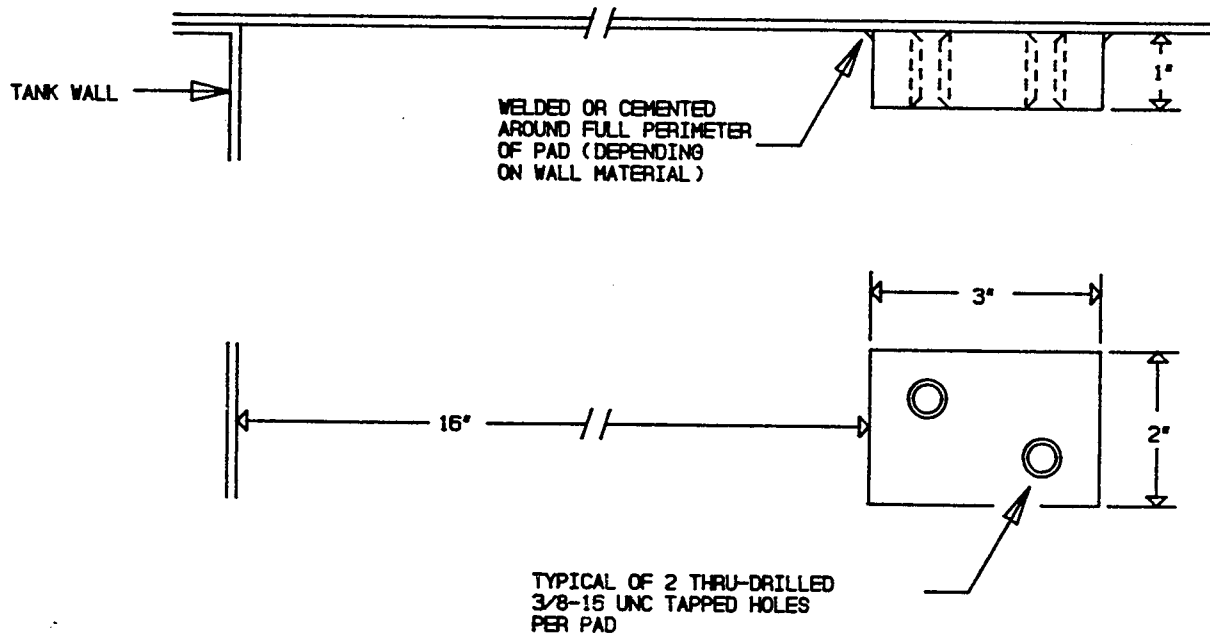


Figure 7 Interface Dimensions for Supplier-Provided Hydraulic
Loop-Feed Switch (Cont'd)

3.14.1.2 Component accessibility.- All IRU's subject to failure shall be mounted in such a way that they are accessible for testing or replacement without removing any other components and without the need to power down the redundant backup components. Electronic components shall be mounted on plug-in cards for ease of servicing.

3.14.1.3 Diagnostic capabilities and repair.-

3.14.1.3.1 Repair of failed elements.- Repair of failed elements shall be accomplished only when those elements are in off-line or inactive status. Defective elements shall be identified through use of diagnostic software and test equipment or through the formation of a test subsystem composed of off-line elements. In no event shall on-line elements be used as part of an off-line test subsystem. Means shall be provided to verify that a repaired element is fully operational before it is returned to on-line or standby status.

3.14.2 Supply.- Spare parts-peculiar for oil-filled, pad-mounted compartmental-type transformers will be identified and acquired in accordance with FAA specification FAA-G-1375. Repairable IRU's will be identified and spares requirements quantified from data generated by logistics support analysis (LSA) in accordance with MIL-STD-1388-1. Provisioning lists will be developed from data generated by LSA and formatted in accordance with MIL-STD-1388-2. Determination of spare IRU's to be stocked on-site will be based on calculated or experienced failure rates of the IRU's.

3.15 Training.- Training required to support equipment developed under this specification will be included in the training course for the Looped Power Distribution System.

3.16 Warning signs.- For transformers with loop feed, a separate safety warning sign reading "DANGER: HIGH VOLTAGE LOOP FEED SWITCH. FEED IS FROM TWO DIRECTIONS" shall be installed prominently on the outside of each unit, and inside of each compartment and cabinet. The lettering shall be a minimum of 1 inch high. The warning signs shall be weather proof, and shall be clearly visible from all accesses. The signs shall meet the requirements of ANSI Standard Z35.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Quality assurance.- The contractor shall provide and maintain a quality control program fulfilling the requirements of FAA-STD-013 "Quality Control Program Requirements" and Specification MIL-I-45208, "Inspection Systems Requirements".

The contractors' quality control program shall be a scheduled and controlled plan of events integrating all necessary inspections and tests required to substantiate product quality during design, development, purchasing, subcontracting, manufacture, fabrication, process, assembly, acceptance, packaging, and shipping; and, when required by the contract, site installation. The contractor shall provide the documentation and perform or

addition, the results of the Production Tests listed in the Matrix for a typical unit shall be included in the Qualification Report. Three copies of this report shall be sent to the Contracting Officer for approval prior to the shipment of the units. If so requested in the purchase order, two copies of the report shall be included in each shipment of units from the manufacturer.

The results of those tests listed as Production Tests in the Matrix shall be included with each unit shipped from the manufacturer (two copies).

The transmittal of results from the Sampling Tests listed in the Matrix shall be as specified in the purchase order.

4.2 Requirements.-

- (a) The Requirements Matrix shown below lists the action required of the Contractor to demonstrate compliance with each paragraph and subparagraph of the requirements section of this specification.
- (b) Qualification Tests (QT) need only to be performed once, for each transformer of identical size and design. Separate, complete qualification tests shall be performed for each different size (kVA rating) of transformer unless the Contractor can demonstrate that certain subsystems are identical, in which case Qualification Tests need only to be performed once. Requalification tests are required when changes in design, construction, materials, major assembly methods, or suppliers occur.
- (c) The selection of samples and the schedule for the Sampling Test (ST) shall be in accordance with FAA-G-2100e.
- (d) Production Tests (PT) shall be performed on each manufactured transformer prior to its being shipped from the manufacturing facility. Test results/inspection results from these tests are also required for the qualification report.
- (e) Where specified, Documentation (DOC) showing the design parameter(s) detailed in the specific requirements paragraph shall be submitted. The documentation shall be appropriate for the requirement (drawings, specifications, material certifications, manufacturer's certifications, etc.).
- (f) In the requirements matrix, the entry TTL designates that the paragraph contains only a title, and no other information; INFO designates that the paragraph contains reference information only.
- (g) Paragraphs that contain only administrative requirements are given the entry ADM in the matrix.

3.3	CONST FEAT	TTL
3.3.1.A	GENERAL	DOC
3.3.1.B	GENERAL	DOC
3.3.1.C	GENERAL	DOC
3.3.1.D	GENERAL	DOC
3.3.1.E	GENERAL	QT
3.3.1.F	GENERAL	QT/ST
3.3.1.G	GENERAL	QT/ST
3.3.1.H	GENERAL	QT
3.3.2.A	TANK	QT
3.3.2.B	TANK	DOC
3.3.2.C	TANK	DOC
3.3.2.D	TANK	PT
3.3.2.E	TANK	DOC
3.3.2.F	TANK	DOC
3.3.2.G	TANK	DOC
3.3.2.H	TANK	DOC
3.3.2.I	TANK	DOC
3.3.2.J	TANK	DOC
3.3.2.K	TANK	PT
3.3.2.K.1	TANK	PT
3.3.2.K.2	TANK	PT
3.3.2.K.3	TANK	PT
3.3.2.K.4	TANK	PT
3.3.2.K.5	TANK	PT
3.3.2.K.6	TANK	PT
3.3.2.K.7	TANK	PT
3.3.2.K.8	TANK	PT
3.3.2.K.9	TANK	PT
3.3.2.L.1	TANK	PT
3.3.2.L.2	TANK	PT
3.3.2.L.3	TANK	PT
3.3.2.1.A	TK GND	DOC
3.3.2.1.B	TK GND	DOC
3.3.2.1.C	TK GND	DOC
3.3.2.1.D	TK GND	DOC
3.3.2.1.E	TK GND	DOC
3.3.2.1.F	TK GND	PT

3.3.3.1.E	GEN'L REQ'TS	DOC
3.3.3.1.F	GEN'L REQ'TS	QT/ST
3.3.3.1.G	GEN'L REQ'TS	QT/ST
3.3.3.1.H	GEN'L REQ'TS	DOC
3.3.3.1.I	GEN'L REQ'TS	DOC
3.3.3.2	MAT'L REQ'TS	DOC
3.3.3.2.1	STEEL	DOC
3.3.3.2.1.A	STEEL	DOC
3.3.3.2.1.B	STEEL	DOC
3.3.3.2.1.C	STEEL	DOC
3.3.3.2.1.D	STEEL	DOC
3.3.3.2.2	FIBERGLASS	DOC
3.3.3.2.2.A	FIBERGLASS	DOC
3.3.3.2.2.B	FIBERGLASS	DOC
3.3.3.2.2.C	FIBERGLASS	DOC
3.3.3.2.2.D	FIBERGLASS	DOC
3.3.3.2.2.E	FIBERGLASS	DOC
3.3.3.2.2.F.1	FIBERGLASS	QT
3.3.3.2.2.F.2	FIBERGLASS	QT
3.3.3.2.2.F.3	FIBERGLASS	QT
3.3.3.2.2.F.4	FIBERGLASS	QT
3.3.3.2.2.F.5	FIBERGLASS	QT
3.3.3.2.2.F.6	FIBERGLASS	QT
3.3.3.2.2.F.7	FIBERGLASS	QT
3.3.3.2.2.F.8	FIBERGLASS	QT
3.3.3.2.2.F.9	FIBERGLASS	QT
3.3.3.2.2.G	FIBERGLASS	DOC
3.3.3.2.2.H	FIBERGLASS	DOC
3.3.3.2.2.I	FIBERGLASS	DOC
3.3.3.2.2.J	FIBERGLASS	DOC
3.3.3.2.2.K	FIBERGLASS	DOC
3.3.3.2.2.L	FIBERGLASS	DOC
3.3.3.2.2.M	FIBERGLASS	DOC
3.3.4.A	TERMINALS	QT
3.3.4.B	TERMINALS	DOC
3.3.4.C	TERMINALS	QT
3.3.4.D	TERMINALS	PT

3.3.4.G.1	TERMINALS	QT/ST
3.3.4.G.1	TERMINALS	QT/ST
3.3.4.G.1	TERMINALS	QT/ST
3.3.4.H	TERMINALS	QT
3.3.4.I	TERMINALS	QT
3.3.4.J	TERMINALS	DOC
3.3.4.K	TERMINALS	DOC
3.3.4.L	TERMINALS	QT
3.3.4.1	MINIMUM DIMENSIONS	DOC
3.3.5	INSTALL	DOC
3.3.5.1	JACKING	DOC
3.3.5.2	ROLLING	DOC
3.3.5.3	LIFTING	DOC
3.3.5.4	MOUNTING	DOC
3.3.6.A	MARKING	DOC
3.3.6.B	MARKING	DOC
3.3.6.C	MARKING	DOC
3.3.6.D	MARKING	DOC
3.3.6.1	MARKING	DOC
3.3.6.1.A	MARKING	DOC
3.3.6.1.B	MARKING	DOC
3.3.6.1.C	MARKING	DOC
3.3.6.1.D	MARKING	DOC
3.3.6.1.E	MARKING	DOC
3.3.6.1.F	MARKING	DOC
3.3.6.1.G	MARKING	DOC
3.3.6.1.H	MARKING	DOC
3.3.6.1.I	MARKING	DOC
3.3.6.1.J	MARKING	DOC
3.3.6.1.K	MARKING	DOC
3.3.6.1.L	MARKING	DOC
3.3.6.1.M	MARKING	DOC
3.3.6.1.N	MARKING	DOC
3.3.6.1.O	MARKING	DOC
3.3.6.1.P	MARKING	DOC
3.3.6.1.Q	MARKING	DOC
3.3.6.1.R	MARKING	DOC
3.3.6.1.S	MARKING	DOC
3.3.6.1.T	MARKING	DOC

3.3.6.1.Z	MARKING	DOC
3.3.6.1.AA	MARKING	DOC
3.4	ELECT REQ'TS	TTL
3.4.1.A	VOLT RATING	PT
3.4.1.B	VOLT RATING	PT
3.4.2	SINGLE-PH POLARITY	PT
3.4.3.A	THREE-PH ANG DISP	PT
3.4.3.B	THREE-PH ANG DISP	PT
3.4.4.A	INSUL LEVELS	PT
3.4.4.B	INSUL LEVELS	DOC
3.4.5	KVA RATINGS	DOC
3.4.6	DUTY	QT/ST
3.4.7.A	HIGH VOLT TAPS	PT
3.4.7.B	HIGH VOLT TAPS	PT
3.4.7.C	HIGH VOLT TAPS	DOC
3.4.8.A	TEMP	QT/ST
3.4.8.B	TEMP	QT/ST
3.4.8.C	TEMP	QT/ST
3.4.8.D	TEMP	QT/ST
3.4.8.1.A	OPER O/V, U/F	QT/ST
3.4.8.1.B	OPER O/V, U/F	QT/ST
3.4.9	SHORT CKT	QT/ST
3.4.9.1	SHORT CKT	QT/ST
3.4.9.2.A	SHORT CKT	QT/ST
3.4.9.2.B	SHORT CKT	QT/ST
3.4.9.2.C	SHORT CKT	QT/ST
3.4.9.2.D	SHORT CKT	QT/ST
3.4.9.3	SHORT CKT	QT/ST
3.4.10.A	DIELECTRIC STRENGTH	PT
3.4.10.B	DIELECTRIC STRENGTH	PT
5.4.11.A	CONDUCTORS	DOC
5.4.11.B	CONDUCTORS	DOC
5.4.11.C	CONDUCTORS	DOC
3.4.12	IMP VOLT	PT
3.4.13.A	SERVICE CONDITIONS	QT/ST
3.4.13.B	SERVICE CONDITIONS	QT/ST
3.4.13.C	SERVICE CONDITIONS	QT/ST
3.4.13.D	SERVICE CONDITIONS	QT/ST
3.4.13.E	SERVICE CONDITIONS	QT/ST
3.4.13.F	SERVICE CONDITIONS	QT/ST

3.5	OIL	DOC
3.5.1.A	PHYSICAL PROP	QT
3.5.1.B	PHYSICAL PROP	QT
3.5.1.C	PHYSICAL PROP	QT
3.5.1.D	PHYSICAL PROP	QT
3.5.1.E	PHYSICAL PROP	QT
3.5.1.F	PHYSICAL PROP	QT
3.5.1.G	PHYSICAL PROP	QT
3.5.1.H	PHYSICAL PROP	QT
3.5.2.A	ELECTRICAL PROP	QT
3.5.2.B	ELECTRICAL PROP	QT
3.5.2.C	ELECTRICAL PROP	QT
3.5.2.D	ELECTRICAL PROP	QT
3.5.3.A	CHEMICAL PROP	QT
3.5.3.B	CHEMICAL PROP	QT
3.5.3.C	CHEMICAL PROP	QT
3.5.3.D	CHEMICAL PROP	QT
3.5.3.E	CHEMICAL PROP	QT
3.5.3.F	CHEMICAL PROP	QT
3.5.3.G	CHEMICAL PROP	QT
3.5.3.H	CHEMICAL PROP	QT
3.5.3.I	CHEMICAL PROP	QT
3.6	FUSES	DOC
3.6.1.A	FUSES	DOC
3.6.1.B	FUSES	QT
3.6.1.C	FUSES	QT
3.6.1.D	FUSES	DOC
3.6.1.E	FUSES	DOC
3.6.1.F	FUSES	DOC
3.6.1.G	FUSES	QT/ST
3.6.1.H	FUSES	QT/ST
3.6.1.I	FUSES	QT/ST
3.6.1.J	FUSES	QT/ST
3.6.1.K	FUSES	QT/ST
3.6.1.L	FUSES	QT/ST
3.6.1.M	FUSES	QT/ST
3.6.2	FUSE SPACING	DOC
3.7	CKT BRKR	PT
3.7.1.A	CKT BRKR	DOC

3.7.1.G	CKT BRKR	PT
3.7.1.H	CKT BRKR	PT
3.7.1.I	CKT BRKR	PT
3.7.1.J	CKT BRKR	QT
3.7.1.K	CKT BRKR	QT
3.7.2	C B MTG	DOC
3.8.A	OPT C/V TRANSD & TRANS	QT
3.8.B	OPT C/V TRANSD & TRANS	QT
3.8.C	OPT C/V TRANSD & TRANS	QT
3.8.D	OPT C/V TRANSD & TRANS	QT
3.8.E	OPT C/V TRANSD & TRANS	QT
3.8.F	OPT C/V TRANSD & TRANS	QT
3.8.G	OPT C/V TRANSD & TRANS	QT
3.8.1	SPACE FOR C/V TRANS	DOC
3.9.A	LOOP FEED SW	PT
3.9.B	LOOP FEED SW	DOC
3.9.C	LOOP FEED SW	QT/ST
3.9.D	LOOP FEED SW	QT/ST
3.9.E	LOOP FEED SW	QT/ST
3.9.F	LOOP FEED SW	QT/ST
3.9.G	LOOP FEED SW	QT/ST
3.9.H	LOOP FEED SW	DOC
3.9.I	LOOP FEED SW	QT/ST
3.9.J	LOOP FEED SW	QT/ST
3.9.K	LOOP FEED SW	DOC
3.9.L	LOOP FEED SW	DOC
3.9.M	LOOP FEED SW	PT
3.9.N	LOOP FEED SW	DOC
3.10.A	OPT MIG FOR HYD ACT	DOC
3.10.B	OPT MIG FOR HYD ACT	DOC
3.10.C	OPT MIG FOR HYD ACT	QT
3.10.D	OPT MIG FOR HYD ACT	QT
3.10.E	OPT MIG FOR HYD ACT	QT
3.10.F	OPT MIG FOR HYD ACT	QT
3.10.G	OPT MIG FOR HYD ACT	QT
3.11	RELIABILITY	QT
3.12	MAINTENANCE	TTL
3.12.1	INTERCHANEABILITY	DOC/ADM
3.12.2	SERVICEABILITY	DOC

3.14.1.1.2	COMPONENT ACCESS	QT
3.14.1.3	DIAGNOSTIC CAP & REPAIR	TTL
3.14.1.3.1	REPAIR OF FAILED ELEM	DOC/ADM
3.14.2	SUPPLY	DOC/ADM
3.15	TRAINING	ADM
3.16	WARNING SIGNS	DOC

END OF REQUIREMENTS MATRIX

prevent marring of surfaces. ASIM-D-3951, dated March 8, 1983, "Standard Practice for Commercial Packaging" requirements shall be met for items shipped to the sites. MIL-E-17555 dated July 14, 1987, "Electronic & Electrical Packaging of" requirements shall be met to ensure all items delivered to the FAA Depot are preserved and packaged Level A and Packed Level B. Spares should be prepared in the same manner other than packed Level C.

5.2 Marking.- MIL-STD-129 dated September 25, 1984, "Marking for Shipment & Storage" requirements shall be met for items shipped to the FAA Depot. The following information shall be legibly applied with permanent ink or paint on a minimum of two sides of each package:

- (a) Contract Number and Contract Line Item Number
- (b) Name of Manufacturer
- (c) Package Number _____ of _____ packages
- (d) Transformer, Electrical
- (e) Voltage Rating, XX kV
- (f) Model Number
- (g) Serial Number
- (h) Optional loop feed switches, and number of Switch Gangs
- (i) Number of Phases
- (j) Optional loop-feed switch control method
- (k) Warranty Expiration Date

6. COMMENTS TO CONTRACTING OFFICER/FAA FIELD PERSONNEL

6.1 Contract-specific information.-

- (a) Transformer type _____
- (b) kVA rating _____
- (c) Enclosure material (steel/fiberglass) (per 4.3.4.2) _____
- (d) With or without loop feed switching (per 3.10) _____
- (e) Loop feed switch control mounting options (per 3.11) --

- (a) Inspect overall unit for signs of external damage, including all seals and mating surfaces.
- (b) Check all openings, seals etc. to ensure that they remain impervious to penetration in accordance with 3.4.1.e.
- (c) Check operation of the tank dial-type thermometer, pressure gauge and level gauge as described in 3.4.2.h, -.i, and -.j.
- (d) Inspect the pressure relief valve for correct operation in accordance with 3.4.2.k.
- (e) Check accuracy of output of tank oil temperature and level transducers, as described in 3.4.2.l.
- (f) Verify the correct operation of the high voltage compartment door lock, as described in 3.4.3.1.c.
- (g) Inspect the high voltage compartment for signs of damage to the high voltage bushings, and presence of the parking stands in accordance with 3.4.4.
- (h) Inspect the lifting provisions, described in 3.4.5.3, for integrity and lack of damage.
- (i) Check that the tap changer described in 3.5.7.b freely operates without binding, and locks in place as described.
- (j) Using a DC continuity tester, check the continuity of the high voltage connections and the low voltage connections to ensure that they match that shown in figures 1 and 2.
- (k) Check that the tank is filled to the proper level with insulating oil.
- (l) Inspect high voltage fuses for damage and check their continuity with a DC continuity tester.
- (m) Check that the low voltage circuit breaker mechanisms operate freely. If terminals are accessible, using a DC continuity tester, check that the circuit opens and closes when the breaker handle is tripped and reset respectively.
- (n) Check remote operation of the low voltage circuit breaker in accordance with 3.8.1.g.
- (o) Check operation of low voltage circuit breaker remote position indication, in accordance with 3.8.1.i.

6.3 Lightning protection.- There are no lightning protection features inherent in these transformers. These transformers are meant to be used in a looped primary system protected by a grounded counterpoise. Metallic enclosures and tanks are to be grounded. Fiberglass enclosures have provisions for lightning rod installation and grounding.

6.4 Spare unit provisioning.- It is suggested that, for each TYPE and SIZE of transformer purchased for a particular site, one spare transformer be obtained; if the procurement is for the Depot, then the spare rate should be 1 percent for each type and size (1 each, minimum).